ALTERNATIVE FUELS

It has lurked deep within the earth for millions of years. It has witnessed the rise and fall of ancient civilizations. It was discovered in 1859, spawning the birth of the modern automobile industry. Today, it is the fuel of choice for a majority of the world's cars, trucks, and buses.

Liquid Gold

For more than a century, petroleum has reigned as "King of the Transportation Hill." In the United States alone, we use almost 12 million barrels of oil **each day** to keep us on the move.

It's no wonder that petroleum is often referred to as "black gold." Imagine what the world would be like if we ran out of oil. Let's take a look at that trip to Disneyland you're planning for summer vacation. Are you traveling from the east coast? Well, you'd better leave now — it's a *looooooong* walk to California. I doubt many people would be willing to hike across America just to visit Mickey Mouse.

No one can argue the importance of the automobile in modern society. Americans love the idea that they can hop in their cars and hurtle across the country, even if they never leave the comfort of their own armchairs. Driving has become an important part of our daily lives. In fact, Americans drove their cars over a trillion miles last year. As you can imagine, it takes a lot of vehicles to rack up that kind of mileage — 191 million to be exact. We now own enough cars to put every American in one, and no one would have to sit in the back seat!

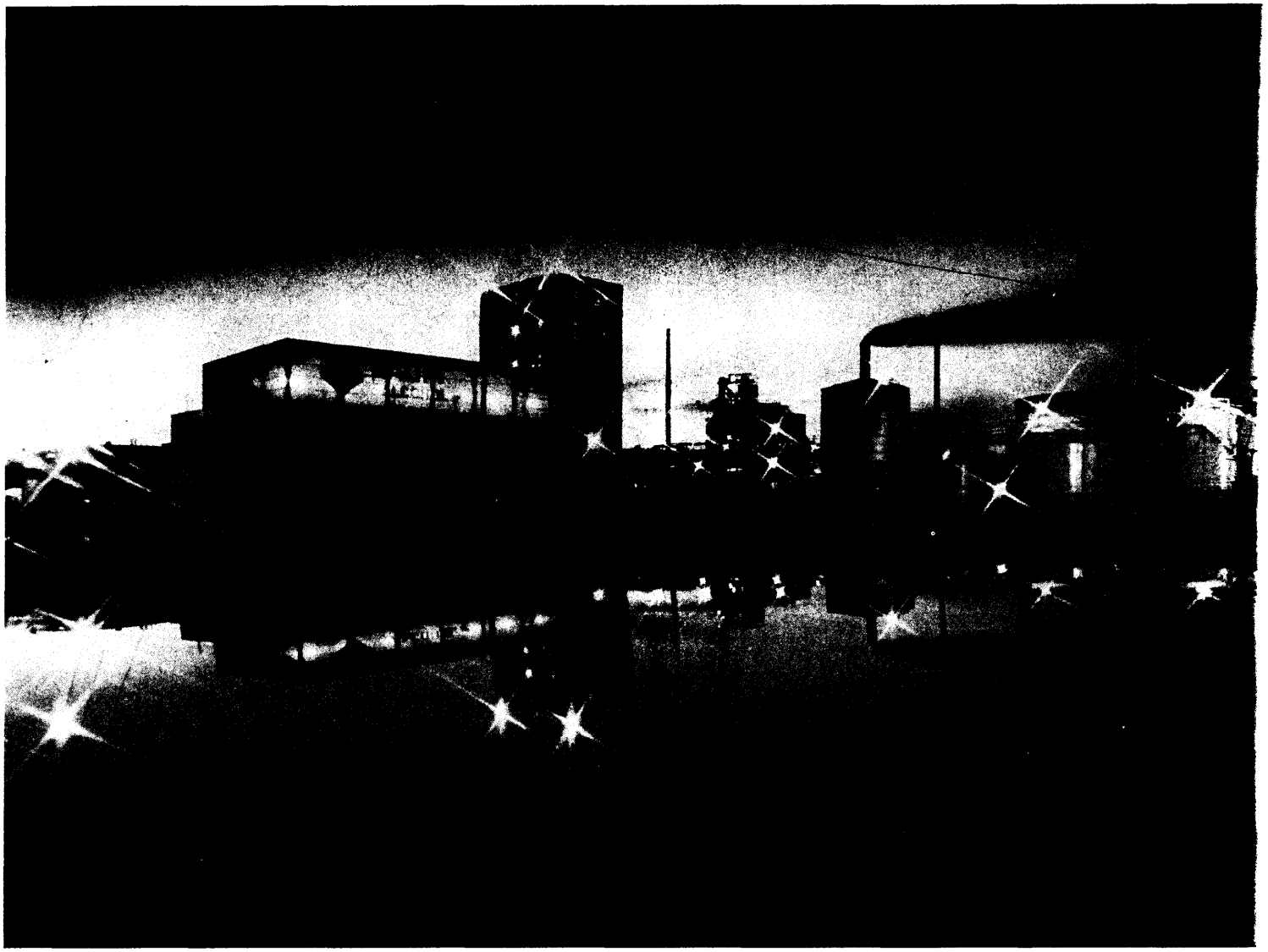
Accommodating this driving habit requires a fuel that is cheap and easy to obtain. Today, more than 99 percent of American cars are powered by petroleum or diesel fuels. Since America's vast transportation network (refineries, pipelines, service stations, etc.) has been designed for petroleum fuels, why would we consider using anything else?

Well, if you've been reading your NEED Fact Sheets, you already know that petroleum is a *nonrenewable* fuel —it won't last forever. Depending on which geologists you listen to, it could be 40 years or 20 before domestic oil wells run dry, and we must turn to oil shale and off-shore wells. Almost everyone agrees that in less than a decade, most quality crude will be in the Middle East. The United States already imports more than 45 percent of its petroleum from other countries. And, thanks to the oil shocks of the 1970s and the Persian Gulf War, Americans are painfully aware of the dangers of depending on foreign oil.

During the twin oil embargoes of the 1970s, drivers waited in line for hours to buy gasoline. When Iraq invaded Kuwait in 1990, the United States went to war to protect the nation's oil supply. It seems the "tiger in our tank" has a voracious appetite, and we will go to any lengths to feed the hungry beast.

Today, over half of every barrel of oil becomes fuel for our cars, trucks, buses, and mopeds. According to Christopher Flavin of Worldwatch Institute, motor vehicles are "at the root of U.S. oil dependence."

But, how will we satisfy our nation's thirst for transportation fuel when the last drop of oil is wrung from the wells? Although petroleum may be a tough act to follow, there are solutions on the horizon...



Archer Daniels Midland

Ethanol production plant at Archer Daniels Midland. ADM is the nation's largest producer of ethanol.

Taking An Alternative Route

Motor vehicles can be powered by many fuels other than gasoline. Alternative fuels, such as natural gas, methanol, ethanol, propane, and electricity, could all help reduce our nation's crude oil "habit."

And a nasty habit it is. Thanks to the millions of cars, trucks, and buses on the road today, more than half of all Americans live in areas that do not meet clean air standards. According to Deborah Bleviss of the International Institute for Energy Conservation, "Motor vehicles generate more air pollution than any other single human activity."

Why are automobiles such notorious polluters? Because the internal combustion engine is an inefficient beast. An automobile engine converts only 20 percent of the energy in a fuel into power that moves the car. The remaining 80 percent is discarded as heat through the exhaust and radiator. In an attempt to increase efficiency, internal combustion engines burn fuel at the highest possible temperature. But the higher the temperature, the higher the harmful emissions. Despite numerous developments in emission control technologies, cars operating on today's gasolines emit a complex mixture of hydrocarbons, nitrogen oxides, carbon monoxide, and carbon dioxide.

Nitrogen oxides (NOx) react in sunlight with hydrocarbon emissions to form ozone, the main ingredient of smog. Ozone pollution damages lung

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tissue and makes it harder for the lungs to function. Smog is especially dangerous to the elderly, children, and people with lung diseases. Nitrogen oxides also contribute to the formation of acid rain.

Carbon monoxide (CO), which comes from incomplete fuel combustion, impairs the ability of the blood to carry oxygen. According to the EPA, motor vehicles emit approximately 80 percent of this poisonous gas found in congested cities. Carbon dioxide (CO_2) is a "greenhouse gas" that contributes to the potential for global warming.

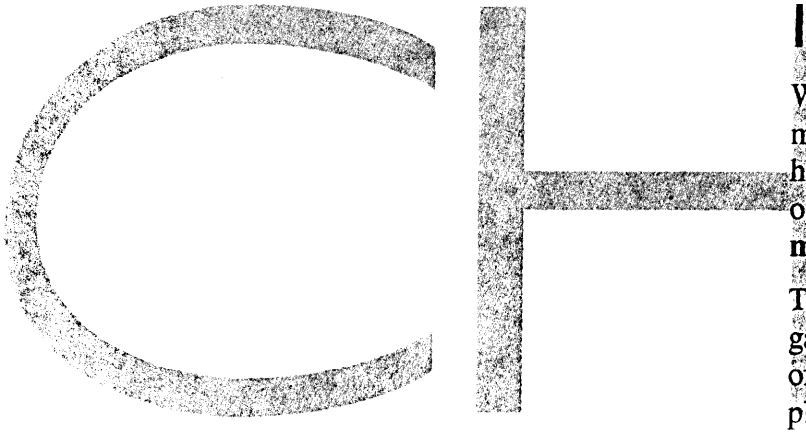
In answer to the public's growing concern over air pollution from motor vehicles, President Bush signed into law the Clean Air Act Amendments of 1990. These amendments set tough new emissions standards for all vehicles to improve air quality in metropolitan areas. Beginning in 1998, in areas with serious air pollution problems, 30 percent of new vehicles purchased for municipal fleets must use alternative fuels.

The federal government is doing its part to encourage the use of alternative fuels. The Energy Policy Act (EPACT) of 1992 was designed to establish a firm energy policy for the United States and to reduce America's dependence on foreign oil. A significant portion of EPACT deals with alternative fuels, requiring their use in certain fleets located in large cities. In addition, a 1993 executive order by President Clinton requires the conversion of thousands of federal fleet vehicles from conventional gasoline to alternative fuels. These mandates will result in 2.0 to 2.5 million alternative fuel vehicles by the year 2010.

In addition to federal regulations, several states are now adopting programs and incentives affecting a broad range of vehicles. California is probably the one state that people most often associate with smog. In fact, there's an old story about a Los Angeles police officer who never felt comfortable when he traveled to the Midwest. When a fellow cop asked him what he didn't like about the Midwest he said, "It's the air. I don't like to breathe anything I can't see."

In response to its growing air pollution problem, California has developed a pilot program requiring auto manufacturers to produce, distribute, and offer for sale more than one million clean burning vehicles by the end of the century. Several Northeastern states have already jumped on the "clean fuels" bandwagon by adopting California's strict new emissions program.

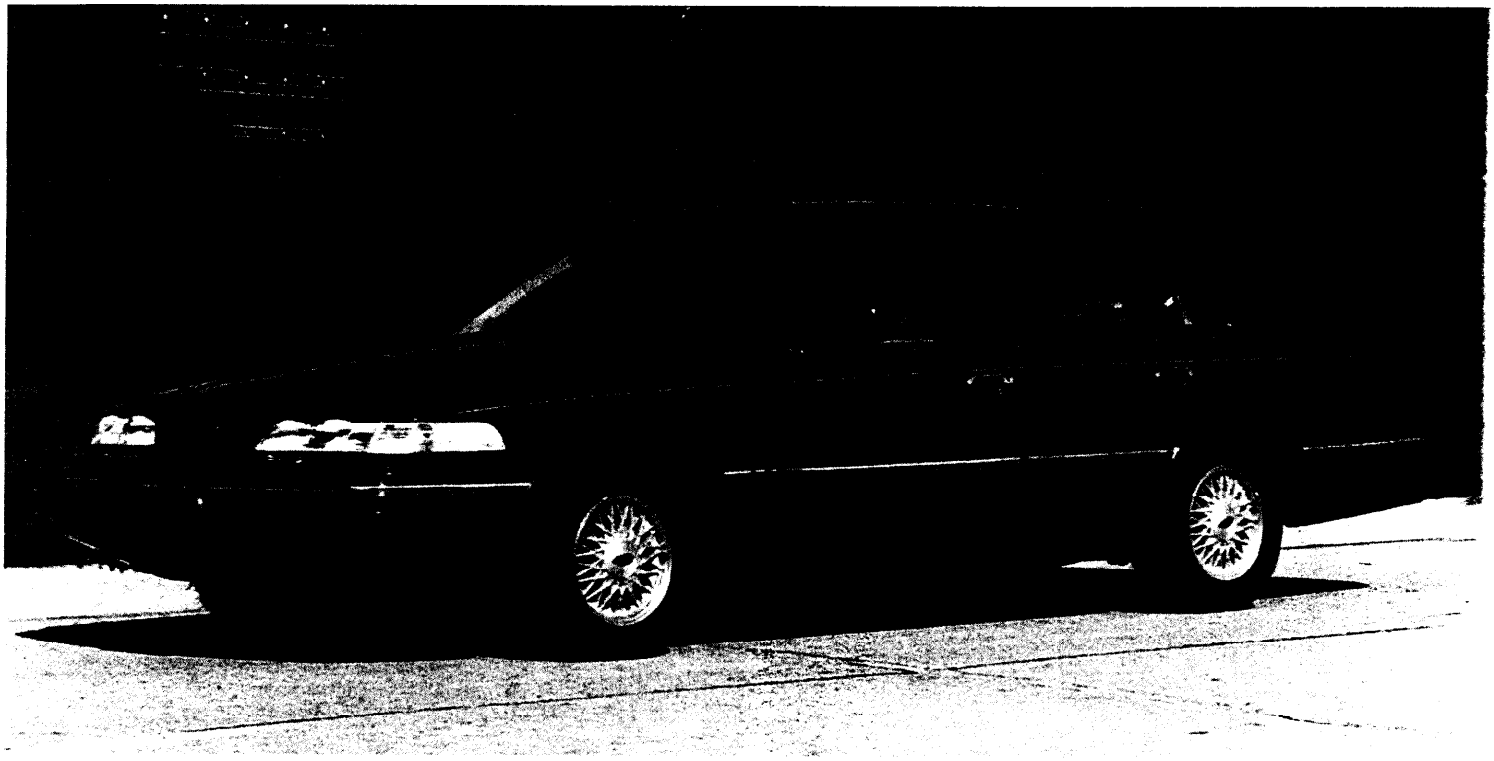
These states are not just playing follow-the-leader when it comes to alternative fuels. Many legislators and government officials are beginning to realize that using alternative fuels can go a long way towards "clearing the air." After more than a century of crude oil dependence and increased air pollution, it may be time to make way for the "alternatives."

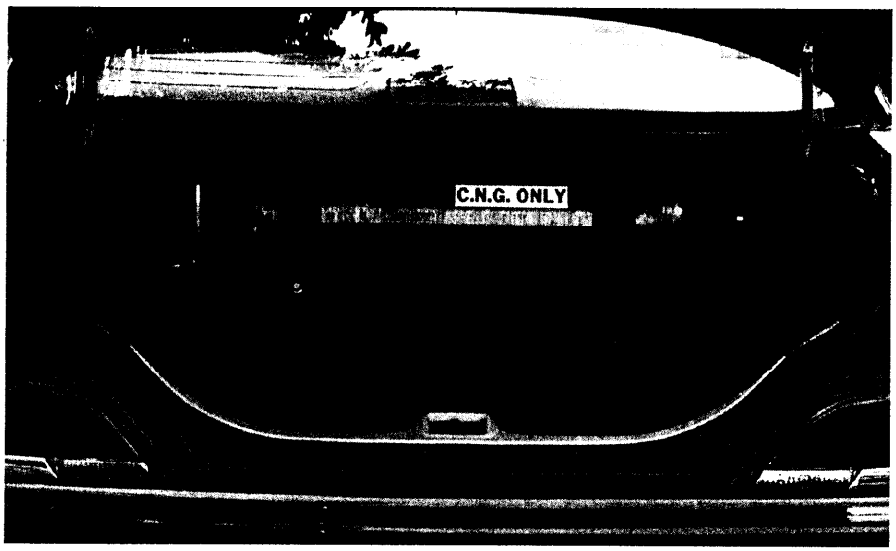


It's A Natural

When you think of alternative fuels, what comes to mind? Futuristic cars racing down 21st century highways? You may be surprised to learn that many of these "new" fuels have been around for years — **millions** of years in fact.

Take natural gas for instance. Like petroleum, natural gas is found underground where it was formed millions of years ago from the remains of tiny sea animals and plants. Today, natural gas is found in more than half the homes and factories in America.





Ford Motor Company

The Crown Victoria Dedicated Natural Gas Vehicle is the first factory produced, dedicated natural-gas powered passenger car manufactured by an automaker.

The same natural gas we use for heating, cooking, clothes drying, and water heating is also a clean burning transportation fuel. Compressed natural gas (CNG) vehicles emit 85-90 percent less carbon monoxide, 32 percent less carbon dioxide, and 90 percent fewer hydrocarbons than their gasoline-powered counterparts. In fact, using natural gas instead of gasoline could lower the amount of pollution spewed into the air by as much as 98 percent!

Natural gas vehicles burn so cleanly that they are often used to carry TV cameras and personalities during marathons. WPXI-TV reporter Kris Long had this to say during the 1995 Giant Eagle/City of Pittsburgh Marathon, "Of course, the runners are very pleased that they'll be running behind natural gas powered vehicles. They won't have problems breathing fumes all day."

Clean air isn't the only advantage to using natural gas as a transportation fuel. When it comes to energy security, natural gas is a "Yankee Doodle Dandy" of a fuel. About 88 percent of the natural gas used in the United States is "Made in America." The rest comes from our friendly next-door neighbors — Canada and Mexico.

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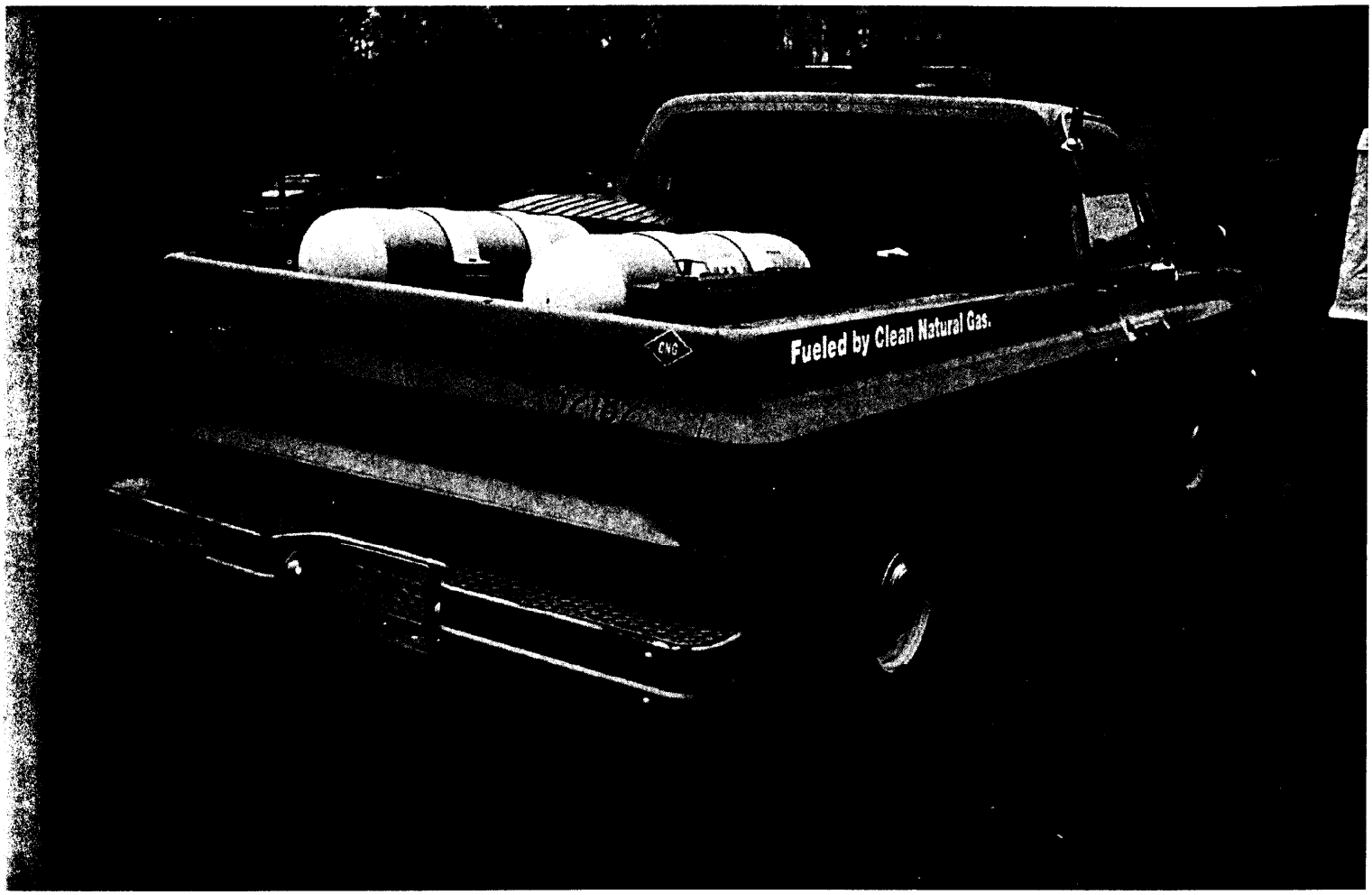


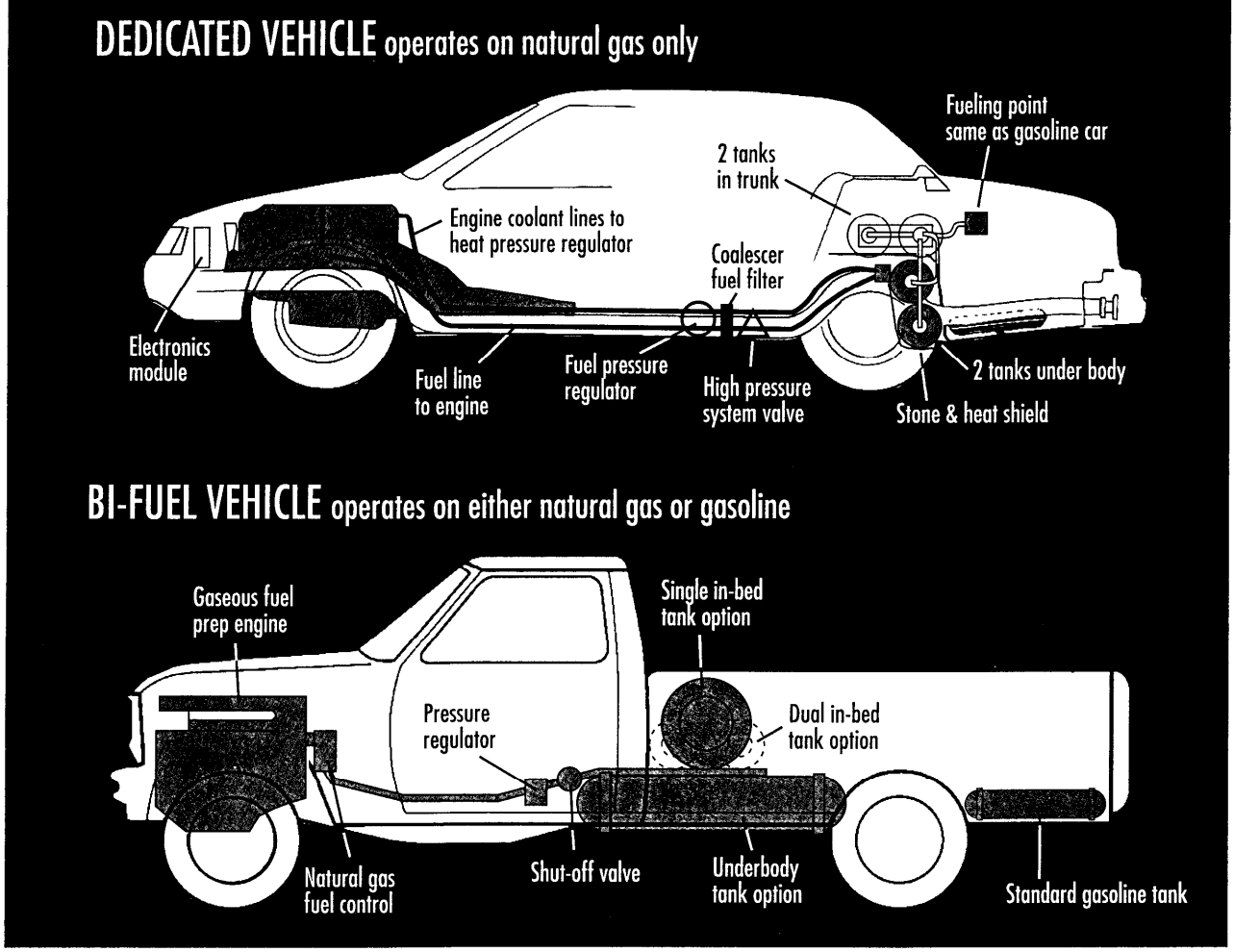
Natural Gas Vehicle Coalition

I know what you NEED kids are thinking, "Isn't natural gas a nonrenewable energy source?" (You **have** been reading your fact sheets!) Alas, 'tis true — natural gas is as nonrenewable as petroleum or coal. However, America has a pretty good supply of natural gas. According to the U.S. Department of Energy (DOE), using existing technology, the United States has a 50–60 year supply of natural gas. If less conventional gas sources are included, your grandchildren's grandchildren will still be using natural gas.

And, it won't matter if those grandchildren live in New York City or Lake Tehatchapoocoo, because natural gas is available in all 50 states. More than one million miles of underground pipelines exist just to transport natural gas from the wells to your home. (Makes you feel kind of important, doesn't it?)

All this hoopla makes natural gas an excellent candidate to fuel our nation's cars, trucks, and buses. In fact, natural gas has been used as a transportation fuel in several countries since the 1930s. Today, there are more than 700,000 natural gas vehicles (NGVs) operating worldwide, with approximately 40,000 right here in the good old U.S. of A.

About now, the future engineers out there are probably wondering, "How the heck does an NGV work?" Well, it's really quite simple. To make natural gas practical for use in a car or truck, it must first be compressed to save space. The gas is pressurized to 3,000 pounds per square inch and stored in special cylinders. When the engine requires fuel, the natural gas leaves the tanks and travels through a high-pressure fuel regulator. The natural gas enters the engine through a specially



designed natural gas mixer, where it is combined with air.

As you have probably already guessed, a car must be converted to run on natural gas. Conversion equipment changes the fuel-to-air mix and engine timing to accommodate natural gas requirements. Unfortunately, it isn't cheap to convert a car to run on natural gas. Conversion equipment will set you back between $2,500 to $3,500, depending on the number of fuel tanks installed. However, the lower price of natural gas when compared to conventional gasoline can help offset the cost of conversion.

Natural gas vehicles can operate in three different modes: on natural gas only ("dedicated" vehicles); on either natural gas or gasoline at the flip of a switch ("bi-fuel" vehicles); or on natural gas and diesel fuel at the same time ("dual-fuel" vehicles). Dedicated vehicles have the best performance record because their engines can be set to take full advantage of the superior *octane rating* of CNG. Octane rating is a number used to measure the anti-knock properties of a liquid motor fuel. Natural gas has an octane rating of 130, compared to 87 to 95 for gasoline. This higher rating means less engine knock, longer spark plug life, up to 24,000 miles between oil changes, and instant winter start-ups.

Despite the many benefits of natural gas vehicles, some people are concerned about the safety of NGVs. "People see this gas tank on the back of a vehicle and wonder what will happen if they are rear-ended," said the Society of Automotive Engineers' DuBois.

Don't worry — a CNG fuel tank is hardly a one-way ticket to the moon. Since CNG tanks must be pressurized, they are actually many times stronger than normal gasoline tanks. Natural gas fuel tanks have been subjected to a number of "severe abuse" tests, such as gunfire, dynamite blasts, bonfires, and collision. In each case, the cylinders passed with flying colors. "We all grew up with gasoline and think it's the safest fuel, but in actuality natural gas is safer,"

said Sheldon Cramer of the Philadelphia Electric Co.'s (PECo) Natural Gas Vehicles Program.

If, in an accident, one of the tanks is broken or punctured, the CNG rises and disperses safely, while gasoline forms puddles that can burn. CNG also burns at a much higher temperature than gasoline (1,200° Fahrenheit compared to 800° Fahrenheit), making accidental combustion of natural gas unlikely.

No matter how safe your CNG tank is, eventually it is going to run out of fuel. This could be a problem—especially for those folks driving around Lake Tehatchapoocoo at 2:00 in the morning. Today, there are only about 1,000 natural gas stations in the United States — a far cry from the multitude of gasoline stations that have sprung up on every corner.

Natural gas vehicles are refueled using either the "slow-fill" or "fast-fill" method. Slow-fill stations take 8–12 hours to refuel a vehicle in comparison to the 2–5 minutes associated with fast-fill stations. Unfortunately, fast-fill stations cost *beau coup* bucks to build. The California Energy Commission calculates that it costs $1,000 to $3,000 per vehicle served to build a natural gas compressor station.

Natural gas tanks also have to be refilled more often than gasoline tanks. Because natural gas contains only about one-fourth as much energy as the same amount of gasoline, NGVs can only travel about 100 miles per tank. Since a typical natural gas powered automobile only carries two fuel tanks, the *range* (distance a car can go before needing to refuel) of an NGV is lower than its gasoline-powered cousin.

For these reasons, most vehicles that use natural gas fuel belong to businesses and public agencies that operate fleets. "Any fleet of large heavy-duty vehicles, such as refuse trucks, buses, or delivery vehicles that return to a home base where they can be refueled would be an ideal candidate for CNG," says Leo B. Thomason, Southwest Gas Corporation's vice president for special projects.

The U.S. Postal Service (USPS) operates the nation's largest fleet of natural gas vehicles, with more than 3,000 vehicles. USPS began experimenting with alternative fuels during the 1970s in response to the energy crisis. A USPS brochure notes, "Of all the fuels tested, natural gas has shown the most promise for meeting the Postal Service's operational needs as well as the numerous environmental regulations being phased in around the country."

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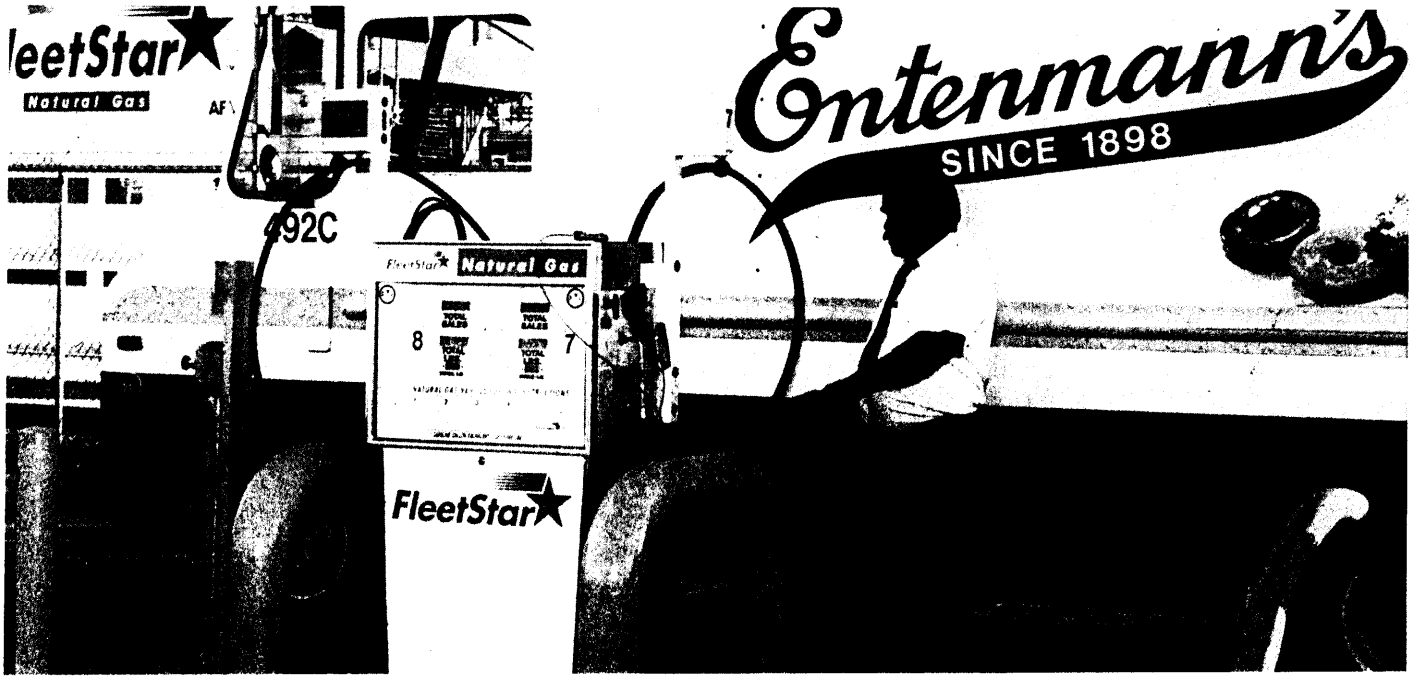


Natural Gas Vehicle Coalition

C_3H_8

It's Not Just For Grilling Anymore

The most widely used alternative fuel in the world is propane. Yes, the very same fuel you use to cook your burgers and dogs every summer. The National Propane Gas Association (NPGA) estimates that there are more than 350,000 propane powered vehicles in the United States, and more than 3.8 million vehicles worldwide. While many other alternative fuels are barely out of the laboratory, propane has been used as a transportation fuel since 1913.

So, what exactly is propane? Propane, also known as liquefied petroleum gas (LPG), is a kissing cousin of natural gas and petroleum. Propane is usually found mixed with natural gas and petroleum deposits in rocks deep underground. About two-thirds of the LPG available today is a by-product of natural gas processing; the remainder comes from crude oil refining.

As its name implies, LPG can be both a liquid and a gas. At normal atmospheric pressure, propane is a colorless, odorless gas. Under moderate pressure and at normal temperatures, propane becomes a liquid 270 times more compact than its gaseous form. When released from its storage container, propane will vaporize and burn as a gas. No other fuel has these capabilities. Natural gas, for instance, must be compressed to extremely high pressures or chilled to minus 259 degrees Fahrenheit before it liquefies. Because propane is easier to store and transport than natural gas, it has been nicknamed the "portable gas."

Propane's chemical formula is C_3H_8 — there are three carbon atoms for every eight hydrogen atoms. This is important because, compared to coal and gasoline, propane is a low hydrocarbon fuel. This means that propane emits less carbon into our air than those other fossil fuels. If you've been paying attention in science class instead of shooting spitballs, you probably already know that carbon combines with air to form carbon dioxide and carbon monoxide. Now let's see who has **really** been paying attention — where have we heard these words before? That's right! Carbon dioxide and carbon monoxide are the "Big Meanies" when it comes to our nation's air pollution problem.

Cars, trucks, and buses fueled by propane produce significantly fewer harmful emissions than either gasoline or diesel. Propane's low-pollution characteristic is one reason why many warehouses use propane-powered forklifts to move inventory safely inside buildings.

In addition, propane powered vehicles are lean, clean-burning machines! Unlike gasoline or diesel fuels, propane won't gunk up a car's "innards" with lead, varnish, or carbon deposits. Simply put, a clean engine means you spend less time and money at the We Bilk You Repair Shop or Lubes-R-Us. Engines fueled by LPG also lead long, productive lives — often lasting two to three times longer than their gasoline-powered counterparts.

The Los Angeles *Times* has been using propane since 1971, and currently has over 300 propane-powered delivery trucks. Several of these trucks have over 900,000 miles on them and are expected to top one million, according to the *Times'* fleet manager Cletus Page.

But wait! There's more! With an octane rating of 104, propane virtually eliminates engine knock, ping, and vapor lock. On a gallon for gallon basis, propane engines deliver from 80 to 95 percent of the mileage of gasoline. This is the highest range of **any** alternative fuel.

What about safety? Here's another vehicle with a pressurized tank stuck in the trunk. Are propane vehicles as safe as NGVs? You betcha! Propane tanks are constructed from carbon steel — even Superman couldn't puncture one (unless it was made from Kryptonite).

Propane may have saved the lives of 54 school children when the bus in which they were riding collided with a gasoline-powered pick-up truck near Alvin, Texas. The collision dented the school bus' fuel tank in two places, but it remained intact. The pick-up truck, on the other hand, bounced off the bus and burst into

flames. According to Alvin Independent School District spokeswoman Shirley Brothers, "The tank took a direct hit, bent the frame and stayed intact. We feel really good about using propane."

As we all know, nothing is perfect. What exactly are the problems associated with this super duper fuel? Well, there's our old friend "Refueling Convenience." He seems to be a stick-in-the-mud for most of the alternative fuels. Although you can refuel your LPG vehicle at any of the 10,000 places that sell propane for cooking and heating, it still doesn't compare to stopping at the nearest gas station for a quick "fill 'er up."

Of course, we can't leave out Refueling Convenience's younger brother, "Conversion Cost." According to the NPGA, it typically costs between $900 and $1,500 to convert a car to run on propane. However, like natural gas, propane is cheaper than gasoline. Substantial fuel savings, along with reduced maintenance costs and longer engine life, can help offset the cost of vehicle conversion. According to a 1989 California Energy Commission study, it takes about one year to recoup the costs of converting a vehicle to run on propane.

Because the cost of conversion can be prohibitive for the typical automobile owner, propane is generally used by people who operate fleets of buses, taxis, or delivery vans. Fleet operators find the cost of conversion outweighed by propane's other beneficial factors. Plus, they can install a storage tank right on their premises, making refueling simple and convenient.

The Yellow, Checker, Star Cab Company in Las Vegas has found propane to be an outstanding fuel. The company began exploring alternative motor fuels in 1980, when it tested CNG for use in its taxis. "We stopped using CNG because we couldn't drive a complete shift without refueling," says Ashley Hall, CEO. "In addition to the decreased driving range, CNG's large storage tanks occupied too much trunk space."

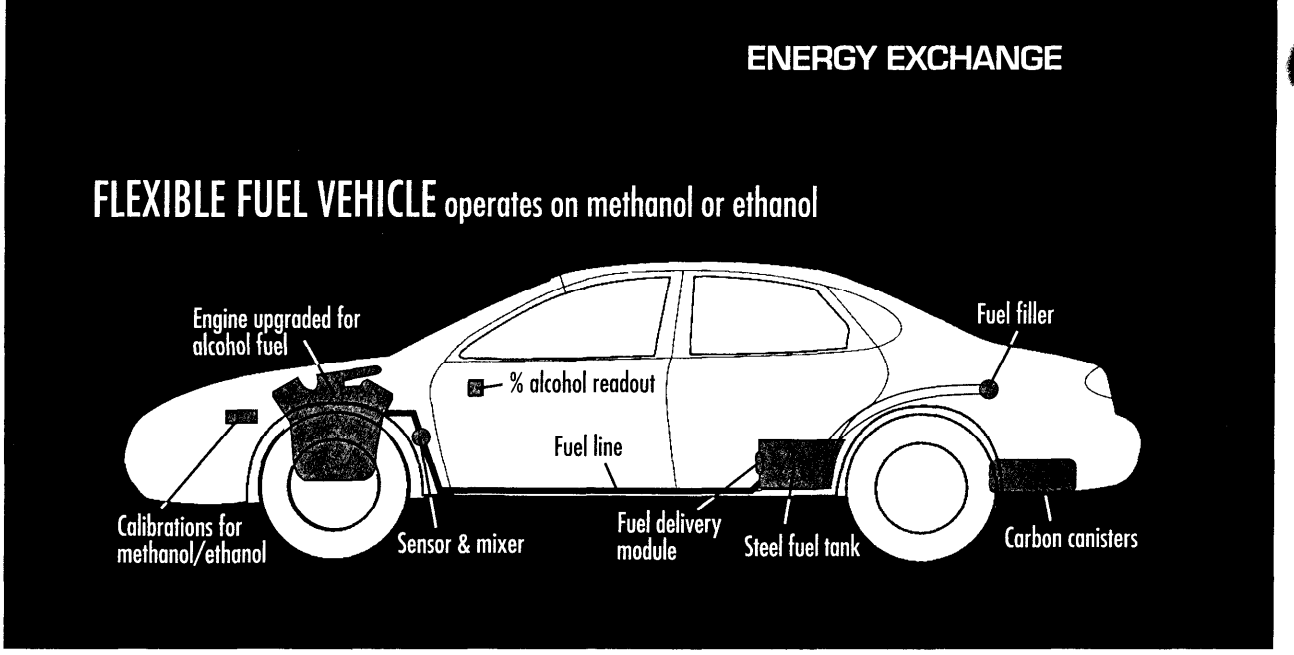
After experimenting with CNG, the company began converting its cabs to propane in 1982, for "environmental and economic reasons," explains Hall. With close to 300 vehicles, the company operates the largest alternative fuel fleet in Nevada.

Make Mine A Double

Imagine turning on your favorite talk show and hearing something like this, "Today on Sally Ricki Donahue, we will be speaking with alcoholic automobiles and the owners who love them." You may wonder, "What's going on here? Are we *driving* our cars to drink?" When it comes to methanol powered automobiles, the answer is yes.

Methanol, or "wood alcohol," is a colorless, odorless, toxic liquid. Methanol is the simplest alcohol (CH_3OH), and can be produced from natural gas, coal, residual oil, or biomass. Today, 90 percent of the methanol used in the United States is produced in the U.S. and Canada and is made almost entirely from natural gas.

Methanol is not a Johnnie-come-lately. It was often used in the early part of the century to power automobiles before inexpensive gasoline was widely introduced. Today, methanol can be found in a number



of household products. In fact, you probably have methanol sitting in your garage right now. Let's take a look. Hmmmm...windshield washer fluid, antifreeze, model airplane fuel (is that yours or your Dad's?). Yep, they all contain methanol.

Methanol's most important use today is as a transportation fuel or fuel additive. Since it has a higher octane rating than gasoline (about 105), a methanol car is a muscle car — but a relatively clean one. Methanol's exhaust contains 35 percent less smog-producing hydrocarbons and 30 to 40 percent less airborne toxics than gasoline. The fuel's superior combustion gives cars (designed to run on methanol) up to 20 percent more horsepower and faster acceleration than gasoline-powered cars. For this reason, methanol has been the only fuel used in Indianapolis 500 race cars for almost 30 years!

Methanol is also much less flammable than gasoline. In fact, methanol fires create less heat and vapor, burn in a more controlled manner, and can be put out with water. An EPA report concluded that using methanol instead of gasoline can reduce fire-related injuries, deaths, and damage costs by as much as 90 percent. This is another reason why methanol is so popular around race tracks (especially with the race car drivers!).

The performance and safety that make methanol the fuel of choice on the auto racing circuit, also makes it an excellent fuel for passenger cars, fleets, trucks, and buses. Vehicles can operate on pure methanol fuel (M100) or methanol blended with 15 percent unleaded gasoline (M85). Because methanol is a liquid fuel, it does not require major changes in the distribution system or in car engines.

Methanol, however, is not without its problems. Though overall pollution is less, methanol produces four to eight times more formaldehyde than gasoline. Formaldehyde — besides being an eye and respiratory system irritant — contributes to ozone formation in the lower atmosphere. Methanol is also poisonous; swallowing a few tablespoons can cause blindness or death.

Unfortunately, alcohol fuels are generally more corrosive than gasoline. Methanol will eat through an ordinary fuel tank faster than you can say, "Fill 'er up with methanol." (Well, maybe not quite **that** fast.) For this reason, methanol tanks must be made from stainless steel and other engines parts must be treated to resist corrosion. These special tanks can add $300 to $500 to the sticker price of the vehicle.

Methanol's biggest drawback is revealed by the gas gauge: it drops like a rock. Methanol has about half the Btu-content of gasoline, which means that it disappears at about twice the rate. Unless drivers are willing to go half as far between fillups, their cars will require larger fuel tanks. Let's face it — who wants to be stopping at gas stations even more frequently?

Methanol powered vehicles can also be more difficult to start in cold weather. This is not good news if you happen to live in the great frozen wilderness in the North (you know, like Minneapolis).

Thankfully, automobile engineers are an innovative bunch — constantly changing and improving the 2,000 pound steel boxes that move us from place to

place. It should come as no surprise that U.S. automakers have responded to the limited driving range of methanol powered vehicles by producing "Flexible Fuel Vehicles" (FFVs).

An FFV can operate on methanol, gasoline, or any combination of the two without the driver having to lift a finger! How is this amazing feat possible? An optical fuel sensor, working with the car's computer system, determines the percentage of alcohol in the fuel stream. The computer then adjusts the engine's fuel air ratio so that the car operates at maximum efficiency. In addition, FFVs don't require two separate fuel tanks — both the gasoline and methanol can share the same tank. FFVs allow drivers to take advantage of methanol fueling stations where they are available, using gasoline as a back-up.

To improve the cold start performance of alcohol fuels, many manufacturers install cold start systems such as block heaters, fuel heaters, and volatility enhancers. A special cold start system developed by Ford enables M-85 powered vehicles to start within five seconds at 20° below zero Fahrenheit.

C_2H_5OH

From Moonshine to Motor Fuel

Ethanol, another alcohol fuel, is just biomass converted into an energy form we can use. Ethanol is made by fermenting sugars found in corn, wheat, and other biomass sources. This process isn't much different from the one used to make vodka or smooth sippin' Tennessee whiskey. In fact, moonshine — that by-product of backwoods stills — is almost pure ethanol.

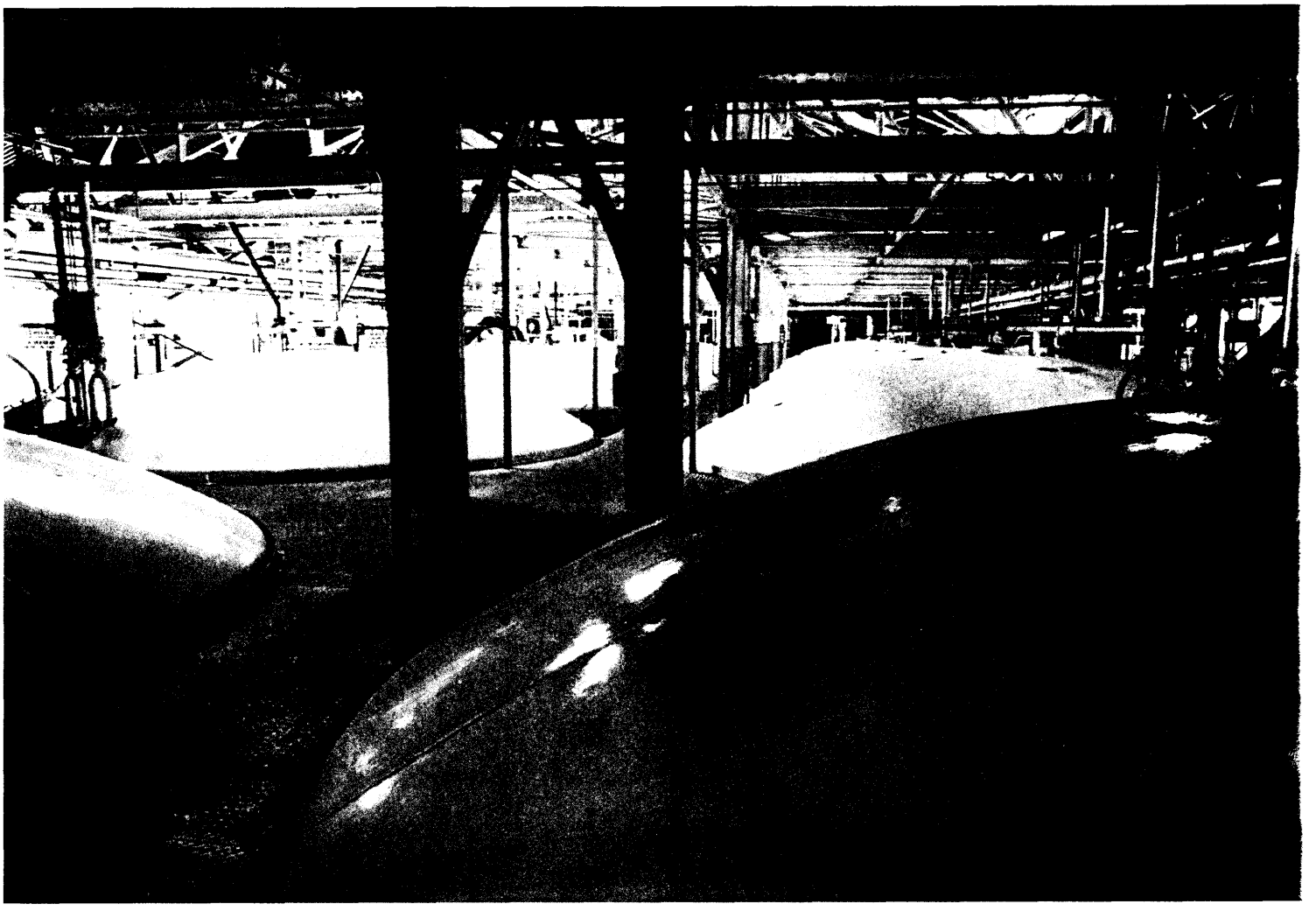
Like several of the alternative fuels, ethanol was present at the dawn of automotive history. In 1908, Henry Ford designed his Model T to run on alcohol, proclaiming it the fuel of the future. It seems, after all this time, he may have been correct.

Ethanol's virtues as an engine fuel are easy to extol. Ethanol burns cleaner and produces less carbon monoxide and nitrogen oxides than gasoline. In addition, making ethanol from grain and other biomass sources can reduce greenhouse gas emissions. Because plants require carbon dioxide for growth, ethanol production creates a "carbon cycle" when the fuel is burned in a car's engine. Simply put, the CO_2 released when ethanol is burned is absorbed by the plants as they grow.

Ethanol has one characteristic that sets it apart from the other alternative fuels mentioned in this article —it's *renewable*. Okay, NEED kids, why is this important? That's right! Because we won't run out of the grain and sugar cane used to make ethanol — we can always grow more. Try growing natural gas or petroleum in your backyard (if you figure out a way to do this, let me know)!

Ethanol can also help reduce our dependence on imported oil. Today, 95 percent of the ethanol used in this country is produced from corn grown in the U.S. — primarily in the large grain-growing states of the Midwest. Because every barrel of ethanol replaces the gasoline produced from two barrels of crude oil, the use of ethanol directly reduces the need for imported oil.

Advocates of ethanol claim the fuel helps America's



Archer Daniels Midland

Ethanol fermentation tanks at Archer Daniels Midland.

farmers. In 1994 alone, ethanol production consumed 535 million bushels of corn. By creating a market for surplus agricultural products, ethanol production added 1.2 billion dollars to farm income and significantly reduced federal farm program costs. Since many federal farm subsidies are aimed at keeping fertile land from producing (in order to hold down overproduction of food crops), using the land to grow grain for ethanol helps both the farmer and the government.

Ethanol's opponents claim that taken on its merits, ethanol doesn't stand a chance in today's marketplace. Since ethanol is not price competitive with gasoline, the government has to slap a 54 cents-per-gallon tax break onto ethanol to make it economically feasible.

This subsidy, while it saves the farm program money, only does so by taking away federal highway money. The gasoline tax is used to fund the Department of Transportation's Federal Highway Administration. This is the agency that repairs and maintains the nation's highways. By some estimates, ethanol's subsidy has drained $1 billion from the nation's transportation system this year alone.

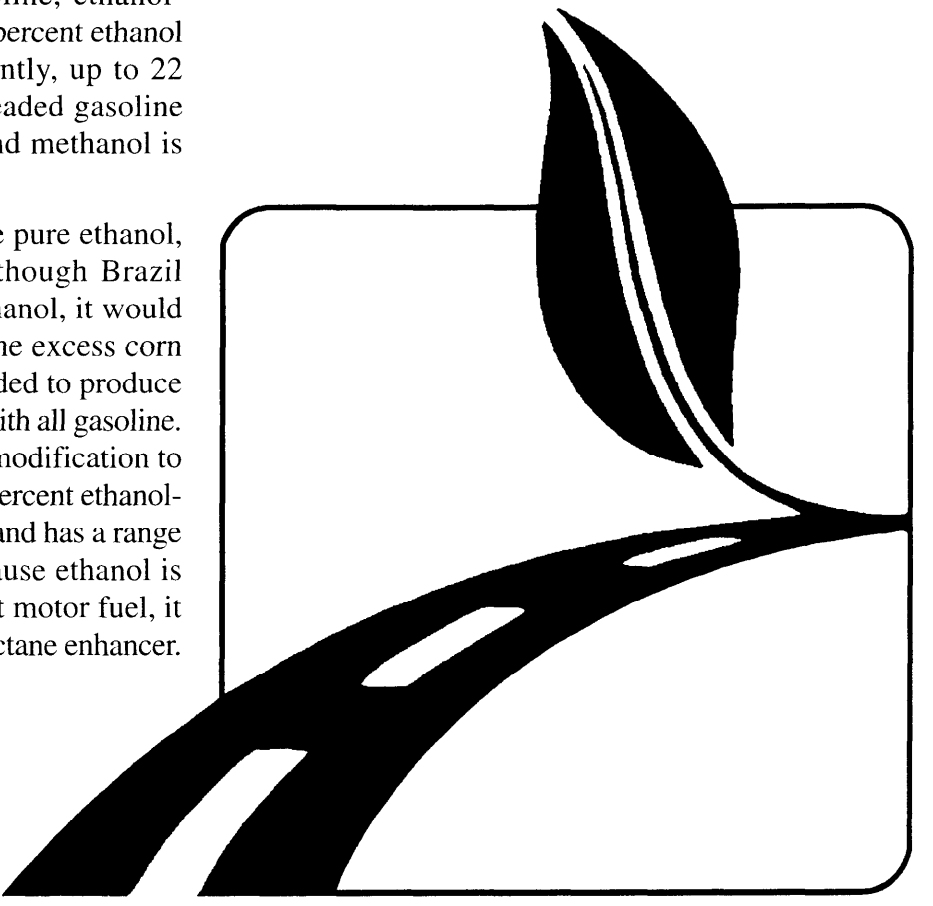
Like natural gas, propane, and methanol, ethanol has the same problems with range. You can't go as far on "corn squeezins" as you can on gasoline. "The Btu content of ethanol is about two-thirds that of gasoline," explains Norm Hinman, manager of the Alternative Fuels Program of the National Renewable Energy Laboratory (NREL), "but a car designed to run on ethanol uses those Btus more efficiently."

Because ethanol is a high octane fuel, it is often blended with gasoline as an "oxygenate" — an octane enhancer that contains oxygen. Octane enhancers boost a car's performance while reducing carbon monoxide emissions. Since ethanol typically costs

ALTERNATIVE FUELS

55 cents more per gallon than gasoline, ethanol-blended fuels usually contain only 10 percent ethanol (this is known as "gasohol"). Currently, up to 22 percent ethanol can be added to unleaded gasoline without any problems. (Our old friend methanol is also used as an octane enhancer.)

You may wonder, "Why don't we use pure ethanol, instead of a 10 percent blend?" Although Brazil operates over half its cars on pure ethanol, it would not be practical to do it here. All of the excess corn capacity in this country would be needed to produce enough ethanol for a 10 percent blend with all gasoline. In addition, most engines need some modification to run on pure ethanol. Fortunately, a 10 percent ethanol-blend requires no engine modification and has a range comparable to regular gasoline. Because ethanol is too expensive to compete as a straight motor fuel, it will probably be used primarily as an octane enhancer.



The Road Ahead

When faced with the daunting task of years of research into alternative fuel technologies and the prospect of building a new transportation infrastructure from scratch, it may seem logical to stick with an old standby like gasoline. After all, most of our vehicles run on gasoline and you can always find a gas station no matter where you go.

This may be true, but it doesn't take into account the fact that gasoline is not a long-term fuel option. The gasoline engine, a creation of the last century, may not be able to meet the needs of the next. "The internal combustion engine has been honed to an extraordinarily fine degree. It's a classic example of an invention that has been tweaked and tweaked to the point where it's very hard to improve," says John H. Gibbons, President Clinton's science adviser.

Faced with tougher emissions standards and new incentives, automakers are shifting their alternative fuel Research and Design programs into high gear. According to former GM President Ed Cole, "We are committed to eliminating the automobile as a factor in the nation's air pollution problem at the earliest possible time. We will have no hesitation in using a power source other than the internal combustion engine, if it will solve the automobile's part of the pollution problem and meet the needs of our customers at a price they can afford."

When considering the future of the nation's transportation needs, the $20,000 question is not, "Will we be driving alternative fuel vehicles?" Instead we should be asking, "**Which** alternative fuel vehicles will we be driving?" Unfortunately, when it comes to alternative fuels, there are no easy answers. I guess we'll just have to wait and see...